

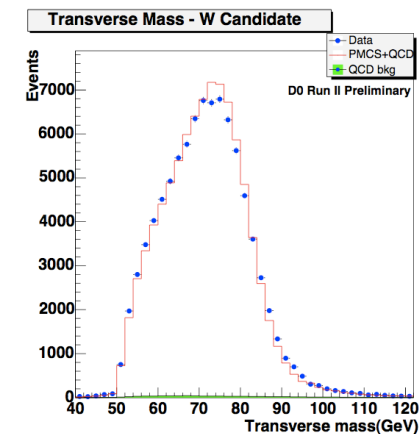
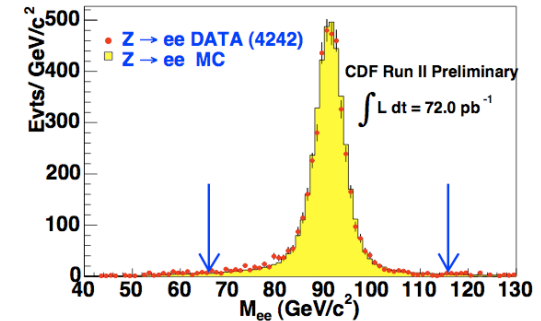
Precision Gluino Mass Measurement at the LHC

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hep-ph/0703298

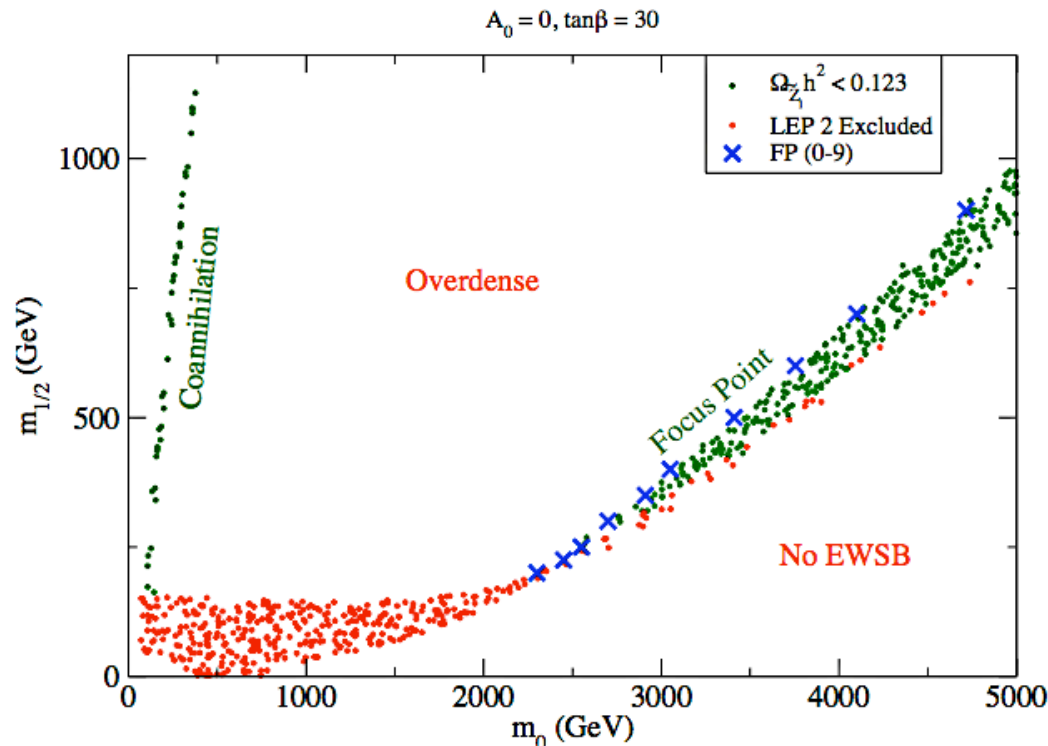
Mass Measurements

- Mass measurements rely on
 - Bump hunting - invariant mass
 - Kinematic endpoints if missing energy is present
 - Difficult if cascade decays are long
- Total rate can also be used to determine mass
 - Can be used in Focus Point region of mSUGRA



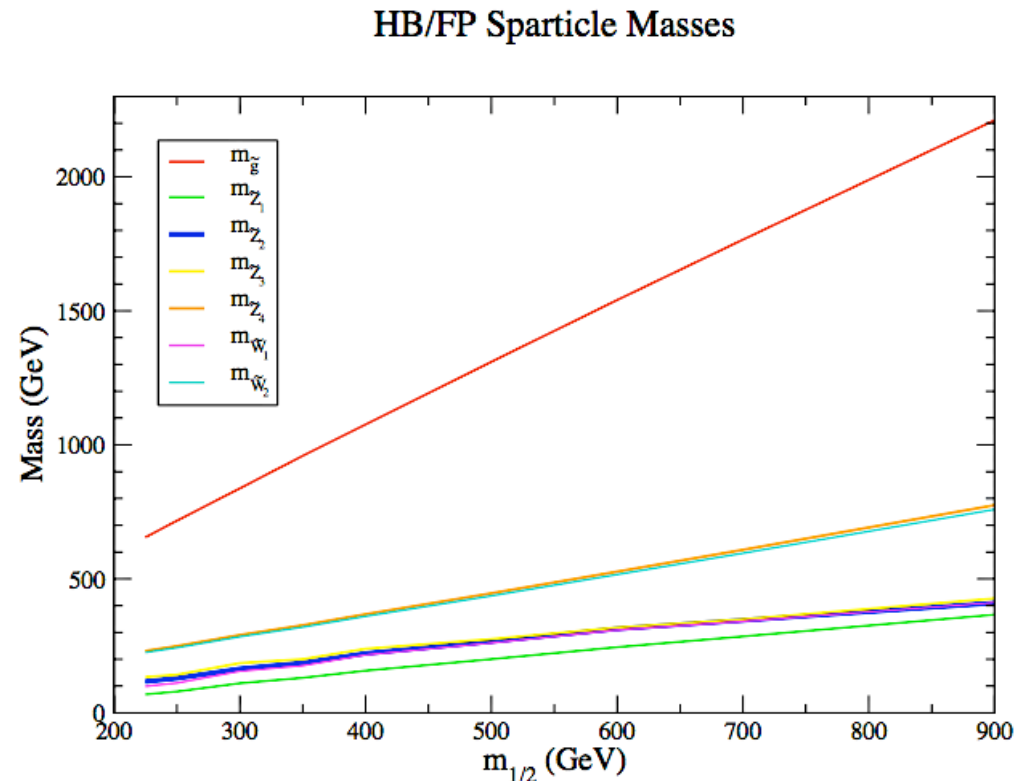
mSUGRA Parameter Space

- Relic density observations favors specific regions
 - $\tilde{Z}_1 - \tilde{\tau}$ coannihilation
 - A-funnel (requires large $\tan \beta$)
 - **Focus Point**
 - Decoupled scalars & mixed higgsino-gaugino DM



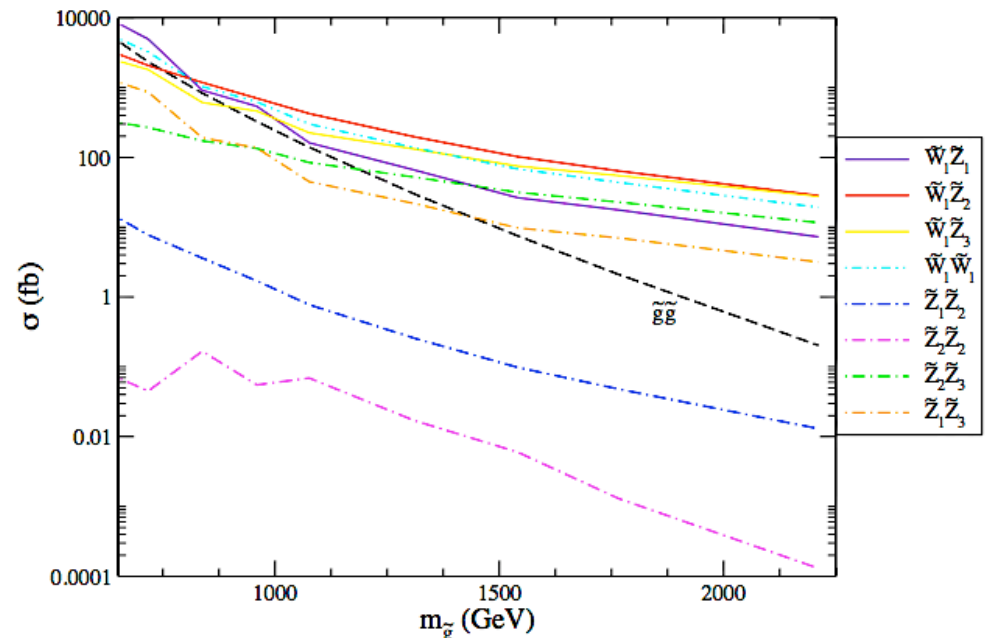
Focus Point Region Spectra

- Neutralinos and charginos typically light
 - soft component of event
- Gluino is heaviest gaugino
 - Hard component of event
- Scalar fermions decoupled
 - few TeV or more



Gaugino Production Cross Section

- Dominated by Neutralino-Chargino production
 - Soft events with high lepton multiplicity
- Gluino pair production rate falls rapidly
 - (key to gluino mass measurement)



Minimal SUSY Cuts

- Apply **C1 cuts**:

$$E_T^{miss} > \min(100 \text{ GeV}, 0.2 M_{eff})$$

$$n(jets) \geq 4$$

$$E_T(j1, j2, j3, j4) > 100, 50, 50, 50 \text{ GeV}$$

$$S_T > 0.2$$

Paige & Hinchliffe

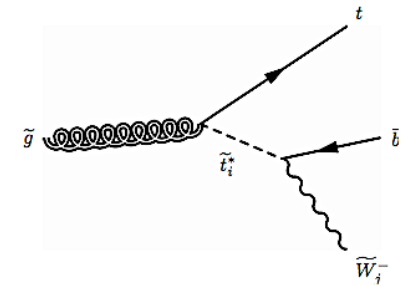
$$M_{eff} = E_T^{miss} + E_T(j1) + E_T(j2) + E_T(j3) + E_T(j4)$$

Characteristics of Gluino signal

- Large jet & b-jet multiplicity

Mercadante, Mizukoshi and Tata

mode	BF
$\tilde{g} \rightarrow t\bar{t}\tilde{Z}_1$	3.9%
$\tilde{g} \rightarrow t\bar{t}\tilde{Z}_2$	14.2%
$\tilde{g} \rightarrow t\bar{t}\tilde{Z}_3$	15.0%
$\tilde{g} \rightarrow t\bar{t}\tilde{Z}_4$	5.6%
$\tilde{g} \rightarrow t\bar{b}\tilde{W}_1 + c.c$	26.8%
$\tilde{g} \rightarrow t\bar{b}\tilde{W}_2 + c.c.$	13.9%



Apply jet cuts:

$$n(jets) \geq 7$$

$$n(b-jets) \geq 2$$

- b-tagging:** 60% of jets that contains B-meson with $p_T(B) > 15$ GeV and $|\eta(B)| < 1.5$ with $E_T(j) > 50$ GeV and $|\eta(j)| < 3$
 - mistag rate:** interpolated between
 - 0.7% for $E_T(j) < 100$ GeV
 - 2% for $E_T(j) > 250$ GeV

SM Backgrounds

- Many SM backgrounds

process	events	σ (fb)	cuts C1 (fb)
QCD ($p_T : 50 - 100$ GeV)	10^6	2.6×10^{10}	–
QCD ($p_T : 100 - 200$ GeV)	10^6	1.5×10^9	1513.3
QCD ($p_T : 200 - 400$ GeV)	10^6	7.3×10^7	3873.7
QCD ($p_T : 400 - 1000$ GeV)	10^6	2.7×10^6	486.0
QCD ($p_T : 1000 - 2400$ GeV)	10^6	1.5×10^4	4.4
$W + jets; W \rightarrow e, \mu, \tau$ ($p_T(W) : 100 - 4000$ GeV)	5×10^5	3.9×10^5	1815.9
$Z + jets; Z \rightarrow \tau\bar{\tau}, \nu s$ ($p_T(Z) : 100 - 3000$ GeV)	5×10^5	1.4×10^5	845.3
$t\bar{t}$	3×10^6	4.6×10^5	6415.8
WW, ZZ, WZ	5×10^5	8.0×10^4	9.3
signal (FP5: $m_{\tilde{g}} = 1076$ GeV)	2×10^5	1.2×10^3	77.5

Most trouble-some backgrounds:
top pair production & QCD jets

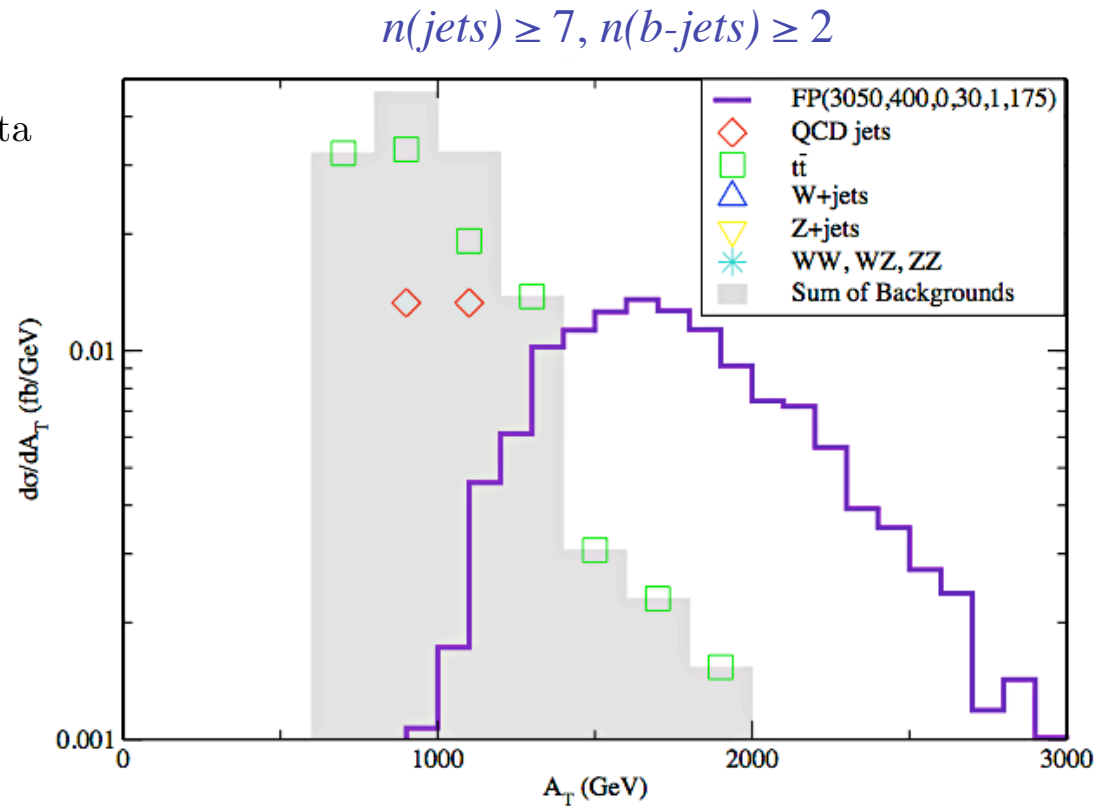
Event Generation

Use Isajet-7.74 to produce 100 fb^{-1} of data

Gluino signal isolated with:

- **C1 cuts**
- $n(\text{jets}) \geq 7, n(b\text{-jets}) \geq 2$
- $A_T \geq 1400 \text{ GeV}$

Optimized for $M_{\tilde{g}} \approx 1 \text{ TeV}$



Augmented effective mass:
$$A_T = E_T^{miss} + \sum_{leptons} E_T + \sum_{jets} E_T$$

Gluino mass extraction

- Signal rate strongly dependent on gluino mass

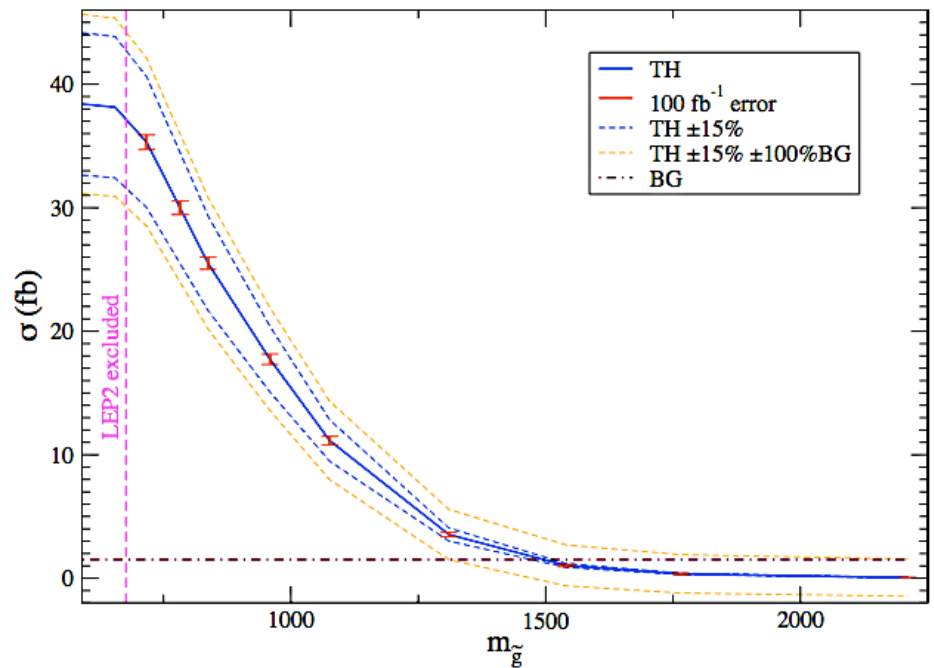
Total rate uncertainties:

$\sim 3\%$ 100 fb^{-1} finite statistics uncertainty

15% Theory uncertainty (NLO calculation / squark decoupling)

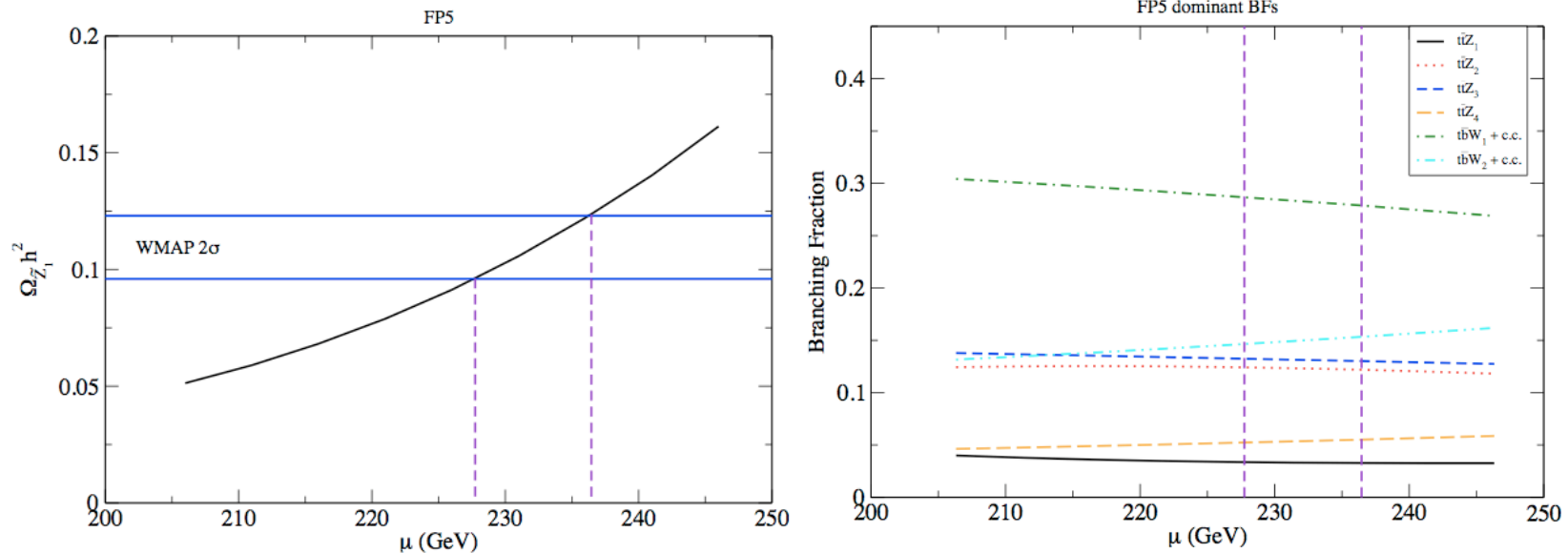
100% Background uncertainty

\Rightarrow 7-10% uncertainty
in gluino mass!



Other sources of uncertainty

- Variability of μ within allowed ranges of Ω_{DM}



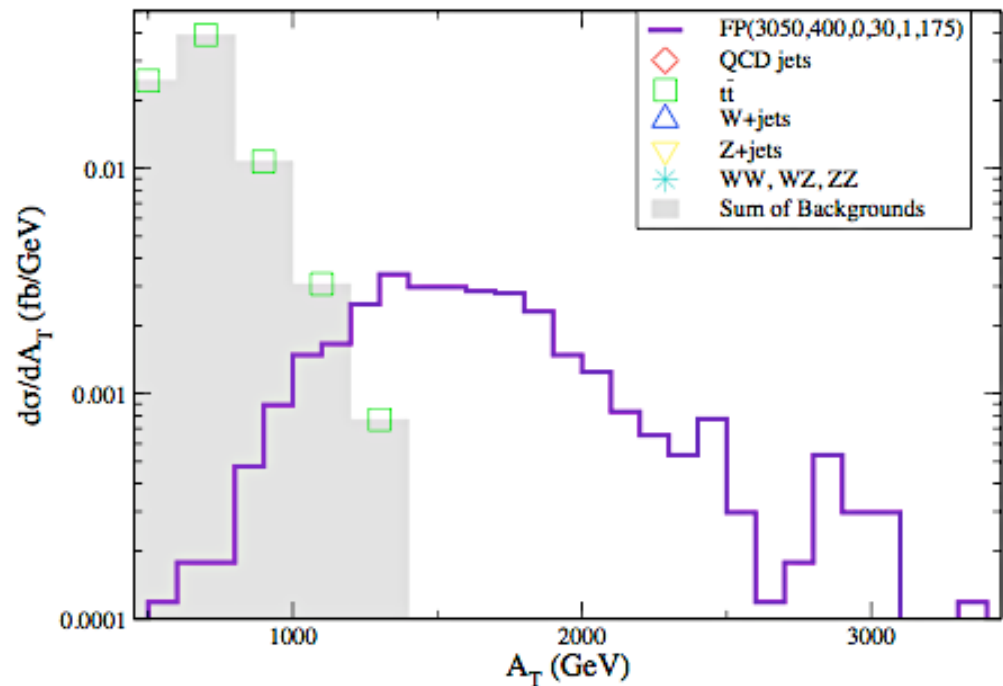
Percent variation in BF of typical modes

- Variability of $\tan \beta$:

m_0	$\tan \beta$	$\sigma(\text{C2})$ (fb)
4090	10	9.92
3150	20	10.45
3050	30	11.15
3000	40	11.04
2970	50	11.17

Leptonic signatures of FP region

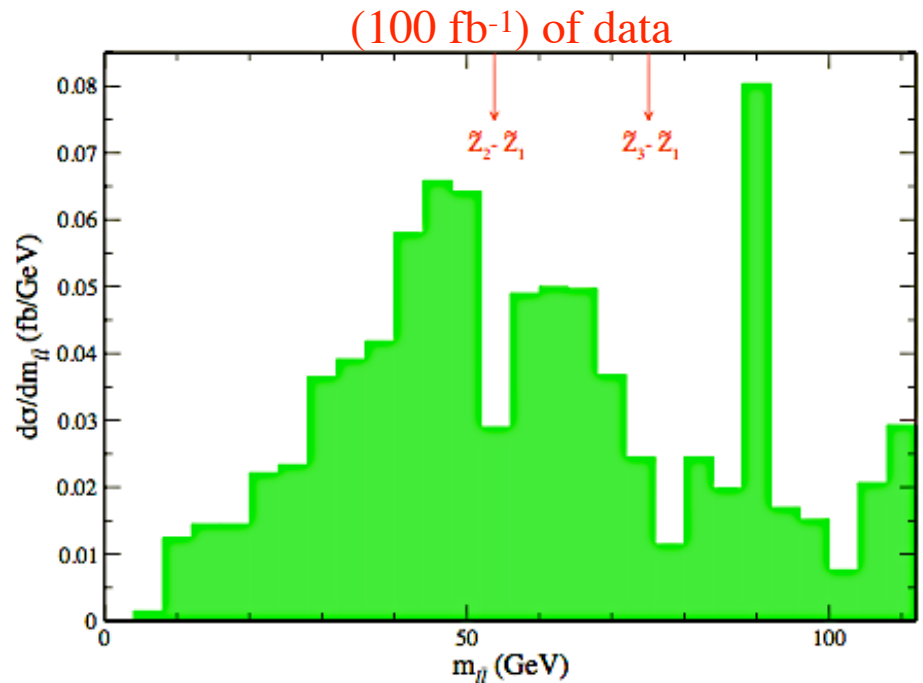
- Leptons are typically soft
 - From lighter Neutralino and Chargino cascade decays
- Isolate leptonic signature by:
 - C1 cuts
 - $n(\text{isolated leptons}) \geq 2$
 - $n(\text{jets}) \geq 4$
 - $n(b\text{-jets}) \geq 2$
 - $A_T > 1200 \text{ GeV}$



Neutralino decays

- Neutralino mass splitting below Z threshold in FP region
 - Dilepton invariant mass has edge
- Edge begins to appear with 100 fb⁻¹ of data
- More well defined with more data

- Verify soft lepton component of signal with hard gluino component
⇒ in FP region



Conclusions

- Events in Focus Point region characterized by
 - Hard events - gluino pair production
 - Many jets and b-jets
 - Large Augmented effective mass
 - Soft events - chargino/neutralino production
 - Many jets and leptons
 - $m_{\tilde{Z}_2} - m_{\tilde{Z}_1}$ and $m_{\tilde{Z}_3} - m_{\tilde{Z}_1}$ below Z resonance
- Gluino mass can be determined to 7-10% from total rate after isolating hard signal